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ASSESSMENT OF ICHTHYOPLANKTON ENTRAINMENT AT PICKERING 'A' NGS USING A PUMP/NET IN LAKE SYSTEM

Report No 85-59-K

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ABSTRACT

Annual entrainment at Pickering 'A' NGS was estimated for alewife as 13.6 X 10^6 larvae and 409 X 10^6 eggs. A substantial portion of eggs an larvae entering the intake were dead due to natural mortality (41%-81%) prior to entrainment. Viable eggs and larvae, immediately following entrainment showed mortalities of 54% and 44% respectively. The latent mortality of entrained eggs was 100% (48 h).

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EXECUTIVE SUMMARY

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At Pickering 'A' NGS entrained alewife eggs and larvae (6mm) were sampled using a high volume (2.8 m^3/min) pump/net in lake system. Annual entrainment was estimated from discharge samples since eggs and larvae appeared stratified in the intake. It was estimated that 13.6 X 10^6 larvae and 409 X 10^6 eggs of alewife were annually entrained, of which a substantial portion (41%-81%) were dead due to natural mortality prior to entrainment. Immediately following entrainment, the number of live eggs and larvae were reduced by 54% and 44% respectively. Eggs collected and incubated in the discharge showed 100% mortality after 48 h. In contrast, eggs collected from the intake resulted in only 15% mortality after 48 h.

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To Mr. F.J. Kee
Director of Research

ASSESSMENT OF ICHTHYOPLANKTON ENTRAINMENT AT PICKERING 'A' NGS USING A PUMP/NET IN LAKE SYSTEM

INTRODUCTION

The entrainment of ichthyoplankton in the cooling water at generating stations and the subsequent reduction in fish stocks has been the subject of much research. Recently several models have been used to try to assess power plant impacts (Ogawa, 1979; MacCall et al 1983). The usefulness of these models to specific situations has been limited due to the inability of field sampling procedures to provide accurate measures of population size and mortality of entrained ichthyoplankton.

The two most commonly used types of ichthyoplankton field sampling gear have been conical plankton nets and low volume pump samplers (Cada and Loar, 1982). A critical review of ichthyoplankton sampling devices and procedures was presented in Ontario Hydro Research Division Report No 80-186-K. Comparative studies suggest the major problem of sampling devices is sampler avoidance (Leithiser, R.M. et al 1979, Cada, G.F. and J.M. Loar 1982). Other problems include net clogging and subsequent loss of sampling efficiency, low pumping rates, and the extrusion of organisms through the collecting net. The device selected to provide estimates of entrainment mortality at Ontario Hydro generating stations was a pump coupled to a net suspended in a tank. A laboratory evaluation of the device revealed that the method retrieved >85% of round whitefish embryos and eleutheroembryos introduced to the system (Ontario Hydro Research Division (OHRD) Report 82-312-K). In addition, survival averaged more than 90 percent when the pump was operated at velocities of 14 cm/sec and 30 cm/sec for 15 minutes. Neither the pump component or the net component was shown to contribute significantly to mortality.

The objective of this study was to assess ichthyoplankton entrainment at Pickering 'A' NGS using a modified pump/net system.

METHODS AND MATERIALS

The pump/net-in-tank larval fish and egg sampling method, described in OHRDR 82-312-K, was modified for field testing at Pickering 'A' NGS (Figure 1). Field modifications included, (1) mounting a Homelite impeller trash pump onboard a boat, (2) drawing water through a 1.5 M clear plexiglass extension (15 cm dia.) oriented directly into the current flow, and (3) suspending the 263 u larval tow net (0.5 m dia. X 1.0 m long) in the lake. Net suspension was in the lake which allowed increased filtration rates and eliminated the head which previously restricted the volume of water sampled.

The volume of water pumped was 2.8 m^3/min. Net approach velocities were measured using an externally heated thermistor probe, in conjunction with an amplifier/voltmeter system. Measurements were taken in the vertical position. The probe housing was placed against the net at four different locations from mid-net to the collar, as well as one point on the collection bucket.

The pump/net in lake system was evaluated against the stationary 0.5 m conical net by comparing capture effectiveness and mortality of eggs and larvae sampled. Furthermore, the mortality attributable to the pumping rate was determined by examining eggs and larvae collected at two different pumping rates (1.0 and 2.8 m^3/min).

Sampling was conducted at Pickering 'A' NGS, from July 17 to August 17,1984 to coincide with the peak of alewife spawning. Samples were taken at the depth (1.5 m) of peak egg and larvae concentrations in the intake. The discharge was sampled at a depth of 2.5 m.

Preliminary pump/net sampling and gill netting was conducted to determine when maximum densities of alewife eggs and larvae could be expected. When densities greater than 2 individuals per cubic meter were captured, replicate 15 min. samples were taken at the intake and discharge locations.

Samples were sorted for dead eggs and larvae at collection time. Opaque eggs and non-motile larvae were considered dead. The remainder were preserved in 10% formalin, and considered to be live at the time of collection.

The influence of plant entrainment, and/or temperature increase was examined by collecting eggs from both the discharge and intake and incubating each at both locations. Three replicates of 50 eggs were tested, for all combinations of egg source and incubation site.

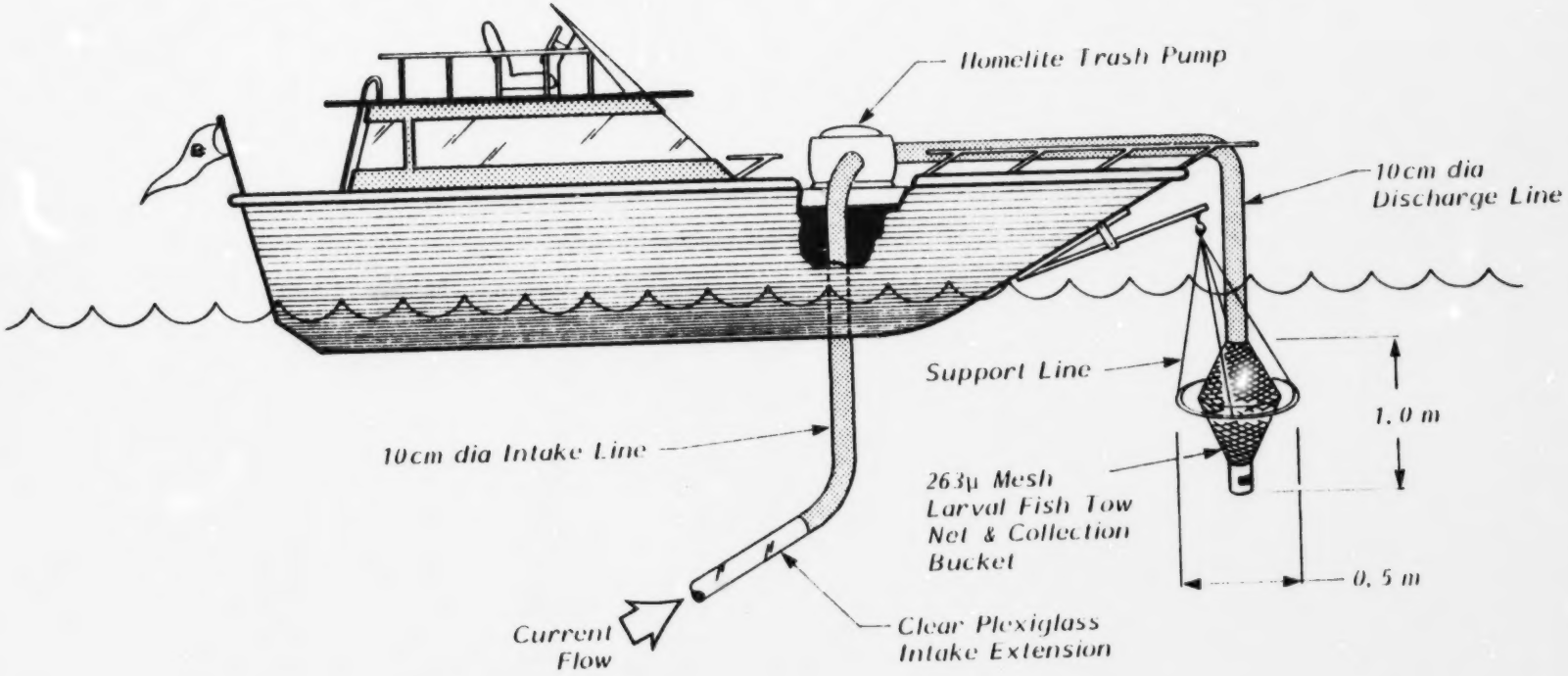

FIGURE 1

ONBOARD PUMP NET IN LAKE SYSTEM
FOR SAMPLING ENTRAINED FISH EMBRYOS AND LARVAE

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Daily density estimates were based on the average catch, and used to calculated the number of larvae entrained through the condenser cooling water system.

$$\text{Daily Entrainment} = \text{number of larvae/m}^3 \times \text{condenser cooling water flow m}^3\text{/s} \times 86400 \text{ (sec)}$$

Condenser cooling water volumes were determined on a daily basis by Ontario Hydro's Hydraulic Studies Department. Annual entrainment values were derived by summing daily entrainment figures during the period of July 17 to Aug 17,1984.

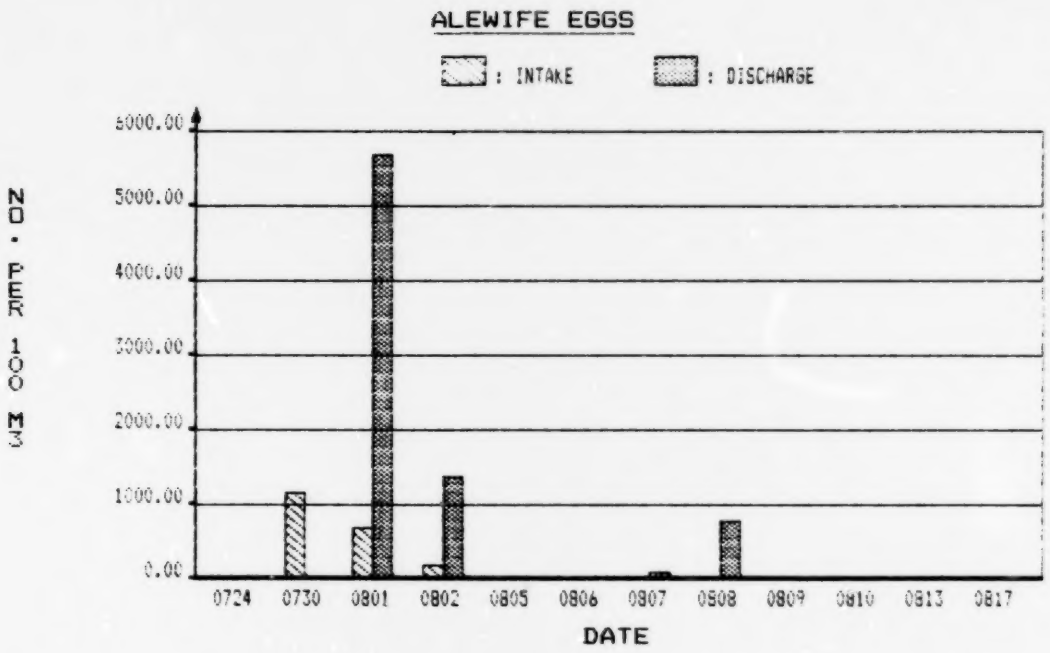
RESULTS

The only two ichthyoplankton species collected were alewife, Alosa peudoharengus and carp, Cyprinus carpio. A total of 12427 eggs and 1158 larvae were collected using the pump/net in lake system between July 18 and August 17,1984. Of these, alewife accounted for >99% of the eggs and 92% of the larval fish (6 mm length).

Peak abundances of alewife eggs were collected between July 30 and August 2, however, eggs were abundant in both intake and discharge samples only on August 1 and 2 (Figure 2). Larval alewife abundances lagged by several days, and peaked on August 6. Only on August 6 were large numbers collected from both intake and discharge samples (Figure 2).

Generally higher densities of alewife eggs were collected in the discharge, while larvae appeared most abundant in intake samples. Presumably eggs and larvae were stratified by depth in the intake current, and more evenly mixed in the discharge. Intake samples may have been collected at a depth where relatively few eggs but large numbers of larvae were present.

Prior to assessing entrainment mortality at the Pickering 'A' NGS the performance of the pump/net in lake system was first evaluated in terms of capture effectiveness and sampler induced mortality. The relative effectiveness of the pump/net in lake was compared to stationary tow net for the collection of eggs and larvae. Results indicated several similarities. Percent egg mortality estimates were similar for both sampling methods ($F_{[1,2]}=0.12$, $p<0.05$). Larval alewife abundance and mortality estimates were also not significantly different for either sampling method ($F_{[1,6]}=1.58$, $p<0.05$ and $F_{[1,6]}=2.85$ $p<0.05$ respectively). The only dissimilarity between the two techniques



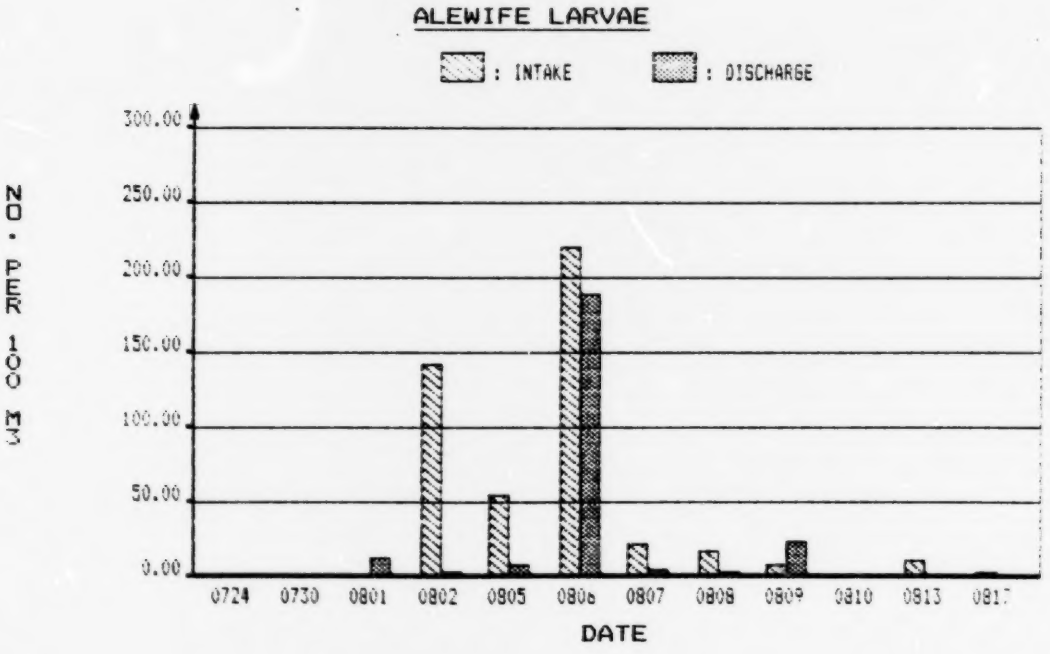


FIGURE 2
ALEWIFE EGG AND LARVAL FISH ABUNDANCES
ESTIMATED FROM PUMP/NET SAMPLES AT PICKERING 'A' NGS
(NUMBER OF LIVE PLUS DEAD PER 100 CUBIC METERS OF WATER)

was that the pump/net in the lake system collected a significantly higher density of alewife eggs (766±101/100 m^3) than the stationary tow net (248±69/100 m^3), ($F_{[1,2]}$=35.8, $p<0.05$). It is interesting to note that the stationary tow net filtered 33% more water than the pump/net system over the 15 minute sampling period. All of the above comparisons were made using only samples collected from the discharge in order to eliminate any bias due to the apparent stratification in the intake.

Further analyses were conducted to determine if pumping rate contributed significantly to mortality. Results indicated that percent mortality was not significantly different ($F_{[1,4]}$=0.77), between the two rates with percent alive averaging 16±8 at 1.0 m^3/min and 23 ± 10 at 2.8 m^3/min.

The contribution of the collection net to larval mortality was examined in terms of net approach velocities. These velocities were determined at the collection bucket and at points 10, 20, 30 and 40 cm above the bucket. Results indicated that net approach velocities at these points averaged 4.9, 3.2, 3.1, 5.0 and 9.2 respectively. Generally these velocities were below the recommended lethal maximum velocity (6.5 cm/s), for obtaining high levels of larval survival in net collection systems (OHRD Report 80-186-K).

Assessment of ichthyoplankton entrainment mortality using the pump/net in lake system involved estimating the live/dead ratio for both alewife eggs and larvae. Sampling was, however, restricted to the peak occurrence of alewife eggs (Aug 1 and 2) and larvae (August 6). The majority (63%) of the eggs entering the intake were alive (Table 1). Of these, a significant mortality (54%) of live eggs occurred following entrainment ($F_{[1,8]}$=13.6, Table 1). It is interesting to note however, that the percent live eggs entering the intake varied significantly between the two collection days (44% and 81% on Aug 1 and Aug 2 respectively). Approximately half of the larvae entering the intake were alive (41%). A significant mortality (44%) of live larvae was observed following entrainment of alewife larvae ($F_{[1,5]}$=9.16, Table 1).

Latent mortality of alewife eggs collected from the discharge and incubated either in the discharge or intake resulted in complete mortality at 48 h (Table 2). Alewife eggs collected from the intake and incubated in the discharge and intake averaged mortalities (48 h) of only 15% and 11% respectively.

TABLE 1

PERCENT LIVE/DEAD ESTIMATES OF ALEWIFE EGGS AND LARVAL FISH COLLECTED ON DATES OF MAXIMUM ABUNDANCE AT PICKERING 'A' NGS

ALEWIFE EGGS (AUG 1 and 2)	INTAKE	DISCHARGE
LIVE	63	29
DEAD	37	71
ALEWIFE LARVAL FISH (AUG 6)		
LIVE	41	23
DEAD	59	77

TABLE 2

PERCENT MORTALITY OF ALEWIFE EGGS AFTER 24H AND 48H INCUBATIONS UNDER INTAKE AND DISCHARGE TEMPERATURE REGIMES - VALUES REPRESENT AN AVERAGE OF THREE REPLICATES OF 50 EGGS

SAMPLING LOCATION	INCUBATION LOCATION			
	DISCHARGE		INTAKE	
	24H	48H	24H	48H
DISCHARGE	37.3	100.0	45.3	100.0
INTAKE	9.3	15.3	10.6	10.6

The daily and annual entrainment of alewife eggs and larvae was calculated, using pump/net in lake samples for both intake and discharge samples (Table 3). Estimates of annual alewife entrainment ranged from 13.6 X 10^6 to 27.2 X 10^6 from the discharge and intake respectively. Annual estimates of alewife eggs entrained ranged from 490.9 X 10^6 to 118.9 X 10^6 from the discharge and intake respectively. Assuming statification of eggs and larvae occurs in the intake; discharge estimates may more closely represent actual entrainment.

TABLE 3

DAILY ENTRAINMENT OF ALEWIFE LARVAE AND EGGS (X 10^3)
CALCULATED FROM INTAKE AND DISCHARGE PUMP/NET IN LAKE SAMPLES
- PICKERING 'A' NGS JULY-AUGUST 1984 -

DATE	INTAKE		DISCHARGE	
	LARVAE	EGGS	LARVAE	EGGS
JULY 18		47		
19				
20				
23				
24		211		
30	90	65651		
AUG 1	45	39200	668	318989
2	7970	11120	135	76883
5	3090	673	444	1870
6	12400	468	10592	668
7	1200	781	270	5548
8	1010	56	202	4304
9	398	202	1337	1516
10	74	147	0	
13	691	348	0	
17	252			112
TOTAL	27220	118905	13647	409891

DISCUSSION

Reliable estimates of mortality encountered by entrained ichthyoplankton have been difficult to obtain primarily because of poor sampling methodologies. Traditional approaches to sampling have generally included 0.5 m diameter conical nets

and/or low volume pumps (<1.0 m^3) (Leithiser et al, 1979). The reliability of estimates obtained using these procedures has been hampered by one or a combination of the following; 1) volume of water sampled is small, inconsistent, or unknown, 2) lack of controlled depth depth of sampling, 3) high net approach velocities (6.5 cm/s), 4) large variability in sampling induced mortality (Cada and Hergenrader 1978, McGroddy and Wyman 1977, OHRD Report 80-186-K, Leslie 1983). Refinements made to sampling equipment and procedures during this study appear to have overcome the above shortcomings.

Estimates of entrainment at Pickering 'A' NGS using the pump/net in lake system indicated that alewife eggs and larvae are present for only a limited time span and peaked over a one to three day period. The majority of fish (95%) collected were post yolk-sac larvae. Almost half of the larvae observed at the intake were dead. The opaqueness of these fish immediately following collection suggested that the sampling procedure was not responsible. The high mortality of these fish may have been related to the transition of these larvae to active feeding. This period has been suggested to account for a high percentage of larval mortality among marine species (May, 1973).

The mortality immediately attributable to station passage was 54% and 44% for eggs and larvae respectively. Results of the incubation experiment however indicated that after forty-eight hours all of the eggs would have died. Furthermore, results indicated that the cause of death may have been more due to mechanical injury than thermal shock, since eggs collected in the intake but incubated in the dicharge suffered little mortality (15%).

The latent mortality for larvae during this study was not determined. Other studies however, have shown that approximately eighty percent of the total mortality for alewife was caused by mechanical damage and twenty percent was attributable to heat shock and prolonged exposure to temperatures above 28°C (Marcy 1971, 1973).

Annual entrainment of alewife larvae was 13.6 X 10^6. Actual loss of larvae to the alewife population attributable to the station however was probably 2.5 X 10^6 when losses to natural mortality are removed. The above estimate assumed that latent mortality was not significant. The actual loss of eggs was 258 million since only 63% of the 409 million entrained were initially alive at the intake. Estimates of annual alewife entrainment from 1975 to 1977 ranged from a low of 18.5 X 10^6 larvae in 1976 to a peak of 322 X 10^6 larvae in 1977 (OHRD Report 81-211-K). Larval

alewife entrainment during 1984 was closest to the low value observed during 1976.

SUMMARY AND CONCLUSIONS

1) Alewife were the predominant species represented in samples collected from July 18 to August 17. Peak abundances of eggs and larvae were present over July 30 to August 2, and August 2-6 respectively.

2) The pump/net in the lake system appears to be an effective procedure for acquiring abundance and mortality estimates.

3) A significant percentage of the eggs and larvae entering the station are dead.

4) Following entrainment, mortalities of 54% and 44% were observed for eggs and larvae respectively.

5) All entrained eggs were dead within 48 hours. No estimates for larvae were obtained.

6) Actual number of eggs and larvae cropped by the intake of cooling water by Pickering 'A' NGS appeared to be 258 and 2.5 million respectively.

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